Automatic Generation of Context-Based Fill-in-the-Blank Exercises Using Vector Space Models and Google n-grams

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INTRODUCTION

According to the American Library Association, approximately 43% of Americans have reading skills at or below the most basic level of prose literacy, the ability to “search, comprehend, and use... continuous texts”[1]. Government and philanthropic funding only indirectly helps one tenth of these nearly 140 million individuals.

To address this shortcoming, we aim to automatically create reading comprehension exercises from existing text passages. We specify that a successful comprehension exercise should challenge a reader’s contextual understanding of the passage’s meaning rather than solely vocabulary knowledge. This poster describes a proposed method of automatically generating fill-in-the-blank exercises designed to target and improve reading comprehension skills, using a unique application of word co-occurrence vector space models and the Google Books n-gram corpus.

CONTEXTUAL AWARENESS

We propose that a good reading comprehension question challenges the reader not with syntactic errors or unusual word choices, but with contextual inconsistencies. We specify that a good “distractor” should make sense grammatically and conceptually within a narrow context, but that only the original word should make sense within the broader context of the entire sentence.

To stay safe during a hurricane.

Example showing distractor applicability in a narrow vs. full context.

When looking at a narrow context, all four words fit in the blank, but when the meaning implied by the entire sentence is taken into account, only one makes sense. Thus, a reader must be actively constructing meaning from the sentence as they read rather than simply decoding the individual words.

CHOOSING BLANKS

We choose to make blanks from words that have strong contextual links to words in the surrounding text, leaving enough context for the reader to understand the sentence’s intended meaning when that word is removed.

To determine contextually-linked words, we consider their cosine similarities in the vector space model GloVe[2], representing their co-occurrence likelihoods. We assume that words that are paired together regularly are likely to have a meaningful contextual and semantic relationship.

We adjust the contextual "scope" to allow us to incorporate potentially relevant information from previously-read text which can contribute to the understanding of the current sentence. We test scopes containing just the current sentence, and those containing 1 and 2 prior sentences.

CHOOSING DISTRACTORS

We explore a unique application of the Google Books n-gram corpus[3] for generating distractors for our fill-in-the-blank questions. We find all words with the same part of speech as the blanked word found in the Google n-grams database.

We select all Google n-grams matching pattern

- replace w_{target} with POS
- replace pronouns with POS
- replace person entities with POS
- for each subtree containing w_{target}
  - get all 2- to 5-grams containing w_{target}

Distractors = all words at index (w_{target})

- select all Google n-grams matching pattern
- distractors + all words at index (w_{target})
- remove synonyms of w_{target}

Algorithm for selecting distractors by finding matching Google n-grams.

EXAMPLE

“It’s written for and put together by the fifth graders,” Dr. Reed said. “It’s written for and put ___ by the fifth graders, Dr. Reed said.” [RR] said

Table 1: Distribution of ratings for all generated questions

Table 2: Percentage of target and distractor words determined to fit each blank

RESULTS & CONCLUSIONS

BLANKS

<table>
<thead>
<tr>
<th>Rating</th>
<th>Percent of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>49.7%</td>
</tr>
<tr>
<td>4</td>
<td>25.6%</td>
</tr>
<tr>
<td>3</td>
<td>15.9%</td>
</tr>
<tr>
<td>2</td>
<td>6.5%</td>
</tr>
<tr>
<td>1</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

Table 1: Distribution of ratings for all generated questions

<table>
<thead>
<tr>
<th>Scope</th>
<th>Target</th>
<th>Distractors</th>
<th>Target</th>
<th>Distractors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 sentence</td>
<td>90.9%</td>
<td>65.4%</td>
<td>98.1%</td>
<td>9.7%</td>
</tr>
<tr>
<td>2 sentences</td>
<td>86.7%</td>
<td>62.8%</td>
<td>97.1%</td>
<td>9.8%</td>
</tr>
<tr>
<td>3 sentences</td>
<td>88.1%</td>
<td>62.8%</td>
<td>96.1%</td>
<td>11.7%</td>
</tr>
</tbody>
</table>

Table 2: Percentage of target and distractor words determined to fit each blank

EVALUATION

Our corpus contained 18 passages obtained from ReadWorks.org (Lexile Level 100 to 1000). For each passage, we generated fill-in-the-blank questions for each scope, resulting in 170 unique questions.

Table 3: Percentage of questions answered correctly

To stay _____ during a hurricane.

Follow these tips to stay safe during a hurricane.

Validly

- Blanks: rate question on a 1-5 quality scale (without distractors)

  - replace w_{target} with POS
  - replace pronouns with POS
  - replace person entities with POS
  - for each subtree containing w_{target}
    - get all 2- to 5-grams containing w_{target}

  Distractors + all words at index (w_{target})

  - select all Google n-grams matching pattern
  - distractors + all words at index (w_{target})
  - remove synonyms of w_{target}

  Algorithm for selecting distractors by finding matching Google n-grams.

Predominantly results suggest that our algorithms are effective at both selecting blanks and generating distractors when automatically creating exercises to test reading comprehension. A single-sentence scope seems the most effective for finding contextually-linked words.

These findings suggest a promising future for the automatic generation of literacy-based exercises.

REFERENCES


