11-411 Final Project Report

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Abstract

Our question generating and answering systems were both designed to be straightforward. We generate questions by parsing articles and transforming sentences that match predefined parse trees into questions. This approach produces reasonably fluent questions, though they have little variety. Our system answers questions by matching key words in the question to the sentences of the article. The answerer then outputs the sentence it considers correct as the question answer. Our report first covers the challenges we faced implementing our solution, then a high level system overview and a detailed discussion of the system components. Finally, we discuss some aspects of our system that we could improve upon if had more time to do so.

1 Major Challenges

Our biggest challenge was being flexible enough to revisit our designs when it turned out that our original ideas were not as viable as we had hoped. During initial planning, we felt that we would need to apply an array of different techniques to bring the system together, including named entity recognition, part of speech tagging, reference resolution, and text classification. However, once we started building the system we were surprised to find that our test results did not always align with our ideas. For instance, using named entity recognition to generate questions did not always generate fluent or even anwerable questions. In the case of our "answer" program, however, the initial simple solution turned out to be quite effective all by itself.

More concretely, the area where we struggled the most was question asking. When we first began considering options, we hadn't learned much about the necessary tools. Parsing in particular wasn't something we had spent much time on in class at that point, so we didn't realize how useful it could be. Instead, we focused on using named entity recognition, an approach that didn't pan out. In addition, while we planned to ask questions of all difficulty levels, while testing we found that our "medium" and "hard" questions were too often either disfluent or unanswerable given the article. This motivated us to restrict our question asking to "easy"-difficulty questions.

2 System Overview

2.1 Question Answering

Our general strategy for answering questions began as a very simple, easy solution to the problem. Initially, we just took key words from the question and chose the sentence with the highest number of key word matches as the answer to the question. If there were multiple sentences that matched, we chose the first occuring one. Since the beginning of the article is more likely to have simple introductory information, this strategy worked well. Though we expected this to be a throwaway solution to just get us started, it worked surprisingly well on questions of all difficulty levels. On our initial basic tests, it answered the majority of the questions (generated in Assignment 4) correctly for all test articles. Since this approach seemed promising, we extended it iteratively to its final form using stemming and text cleaning.

We determined key words for matching by discarding common words that imparted little information such as articles and determiners. One additional word that we removed was the title of the article; its frequency throughout the article caused false positives. After examining our results, we noticed that in some cases, words that should match did not because of different tenses. For example, a question used “pursues” where the article used “pursuing” and thus the system didn’t match the key word and returned a different, incorrect answer candidate. This was problem was addressed via stemming. Cleaning the text was a matter of removing the residual Wikipedia formatting: references, the related article list, images, disambiguation links, and image or link credits which were irrelevant to the questions and caused disfluency. The final improvement was adding pronoun heuristics to increase the fluency and accuracy of the final answer. Pronouns were eliminated by inserting the referent into the answer either by prepending the sentence before the answer candidate or replacing the pronoun with the article’s title. Clearly this latter approach is merely a heuristic, but for the “easy”-difficulty questions we used for testing, it performed well empirically.

2.2 Question Asking

Our question generator generates only easy questions, though we did write code to generate medium and hard questions. In tests, these were deemed too disfluent or unanswerable and removed from the final project. Our final question asker generates questions based on a parse tree. After sanitizing the article, each sentence in the article is parsed using the Stanford Parser and then translated into an internal parse tree representation.

This internal representation allowed us to build parse tree matchers, which allowed us to look for fixed structures within a parse tree. Two such matchers were built: one for “factoid” questions, and one for date-based questions. Additionally, if the answer to the question is a substring of the article title or vice versa, the question is thrown out to keep the questions from being answered correctly by basic restatements of the article title.

3 System Components

3.1 Multi-use components

3.1.1 ArticlePreprocessor

`ArticlePreprocessor` is a module to clean the article text before any other actions. It can take a full article and remove unnecessary text that is not well-formed English. Parenthetical asides and references, the related articles list, images, and disambiguation links are all removed, then the cleaned text is returned. This prevents disfluency in questions and answers with non-English formatting.

`ArticlePreprocessor` also has functionality to split a body of text into sentences, returned as a list. It recognizes periods, question marks and exclamation marks as sentence boundaries. It also removes sentences that contain URL attributions as they are generally also disfluent. The cleaned sentence list is then returned. There are some problems with the sentence separation implemented here. It is rather simplistic and thus does not correctly handle abbreviations like "U.S.", considering the final period to be a sentence boundary. We tried to implement a few heuristics, such as recognizing that if a single non-whitespace letter precedes a period, it cannot be a sentence boundary (since there are no grammatical English sentences that end with a one-letter word). This situation arises with people's names, e.g. "Robert R. Livingston".

3.2 Question Generation

3.2.1 ask

As per the requirements, `ask` takes the file name of the article and the number of questions to generate as parameters and prints a list of questions. It's also possible to use the flag `--verbose` to write the verbose output of the asker and any standard error text to a log file (among the output are sentences from the article being considered for transformation into questions). `ask` uses `ArticlePreprocessor` to clean the article text, and passes the cleaned text to the `EasyQuestion` module to generate questions.

3.2.2 EasyQuestion

Our original idea was to have a series of asking modules, each of which would be consulted to generate questions, and to have each one generate questions of varying difficulty — hence the name `EasyQuestion`. However, after we tried various other asking strategies and found that none of them consistently produced good questions, `EasyQuestion` was our only remaining strategy. This module was meant to be the one that asked "easy" questions. We never developed viable strategies for asking "medium" or "hard" questions.

This component takes a string of article text and an integer representing the number of questions to be produced and returns a list of questions. It uses `ArticlePreprocessor` to separate the text into sentences, and then uses the `Parser` class to obtain a parse tree for each sentence in the article.

The parse trees are passed to each `ParseTreeMatcher` in turn (there are two in the final system, `FactoidMatcher` and `DateMatcher`) to see if they can turn the parse tree into a question.

The matchers return both the question and the answer. If the returned answer is a substring of the article's title (or vice versa), the question is rejected. This feature was added in testing after we discovered that many of the generated questions could be answered coherently with just the article title. After the correct number of questions are generated or if every viable sentence has been checked, the list of questions is returned.

3.2.3 Parser

The `Parser` class is both a Ruby front-end to the Stanford Parser (written in Java) and a postprocessor for taking the Penn Treebank-formatted output of the Stanford Parser and turning it into a syntax tree expressed as Ruby objects. The Ruby class `ParseNode` allows for a true tree structure that contains both the phrase structure and the sentence. This allows for easily searching the parse tree for specific structures, as implemented by `ParseTreeMatcher`.

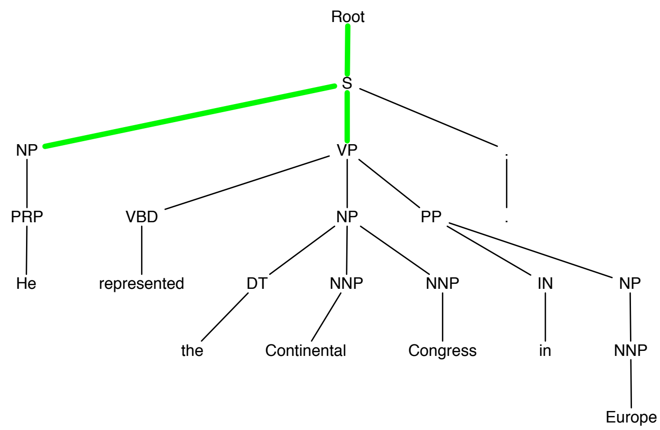
3.2.4 Stanford Parser

The Stanford parser[1] contains Java implementations of several different parsers. We use the optimized probabilistic context free grammar parser. The package provides a script that accepts a file as input and outputs parse trees in text form for each sentence in the input file. This interface proved to be problematic. Each time the parser was invoked it loaded the serialized model from disk, which was time consuming. We therefore modified the Stanford parser to run in an "interactive" mode where it reads from standard in and outputs parse trees for each sentence, only exiting when it receives EOF on standard in. This allows us to launch the parser, and thereby load the serialized model, once during the execution of our code.

3.2.5 FactoidMatcher

The factoid matcher is a subclass of `ParseTreeMatcher`, that matches factoid type sentences as shown in the figure below. `FactoidMatcher` checks whether the tree is of the "factoid" form. If it is, `FactoidMatcher` can take the provided parse tree and turn it into a question by extracting the noun phrase and verb phrase from the tree and prepending the correct interrogative pronoun (who, whose, what) to the verb phrase based on the part of speech tag assigned to the subject of the noun phrase.

[1] `http://nlp.stanford.edu/software/lex-parser.shtml`

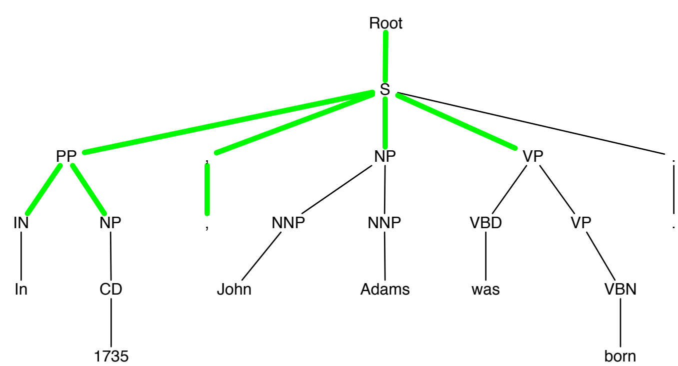


The green lines highlight the substructure searched for

For example, this matcher will translate the sentence "He achieved international fame as the leading Union general in the American Civil War." into the question "Who achieved international fame as the leading Union general in the American Civil War?".

3.2.6 DateMatcher

`DateMatcher` is also derived from `ParseTreeMatcher`, but matches trees of the form shown below. `DateMatcher` checks whether the given parse tree has the substructure shown in the diagram and if the prepositional phrase in the sentence contains a year (four consecutive digits was assumed to be a year). To extract a question from such a sentence, the date is removed, and "in what year?" is appended.



The green lines highlight the substructure searched for

For example, this matcher will translate the sentence "In 1860, he favored Democrat Stephen A Douglas but did not vote." into the question: "He favored Democrat Stephen A Douglas but did not vote in what year?"

3.3 Question Answering

3.3.1 answer

`answer` takes the file name of the article and the file name of the question file and returns a list of answers to the given questions. As with ask, there is a verbose option for debugging. After reading in the article text, answer reads in the questions one at a time and calls the `EasyAnswer` module to extract answers.

3.3.2 EasyAnswer

Like `EasyQuestion`, the name of this component indicates that we intended it to be used as a first solution to answering questions, falling back to more sophisticated answering methods if this method proved insufficient. However, this component is our only question-answering code, and we simply print, "Couldn't answer this question" if it fails (i.e. not enough key words from the question are matched in a sentence in the article.)

`EasyAnswer` takes a question and the full text of an article as input. The key words of the question are extracted by stripping out common words and removing punctuation, both tasks being implemented in the `CommonWords` component. The remaining words are stemmed, and the resulting list of key words is used for answer matching. The article title (always on the first line) is removed from the key word list as well, to avoid false positives. After separating the article text into sentences with `ArticlePreprocessor`, those too are stemmed to ensure consistency over the question and the article. For each of the stemmed sentences, the number of keyword matches are counted and the sentences are added to a list, keeping track of the sentence with the highest score. If two sentences with the same score are found, the first matched sentence has priority. After examining all the possible answers, if there are no sentences that match at least half of the key words, the question is deemed unanswered and `EasyAnswer` returns nil.

If there is a reasonable answer, we check whether the subject is a pronoun (if it is, the first word will be the pronoun, so we only check the first word). If the subject is "it," the previous sentence is prepended so that the referent will be included in the answer. While this is not guaranteed to include the referent, very few coherent English sentences deal with referents further than two sentences back so it will most likely work. If the subject is "he" or "she," we substitute the article title; if it is "they," the title is pluralized and substituted. Finally, we capitalize the answering sentence properly and return it.

3.3.3 CommonWords

`CommonWords` defines the words that we determined to be irrelevant to finding the correct answer. Generally, these words fall into the categories of determiners, auxiliary verbs, interogative pronouns, modals, prepositions, and some conjunctions and adverbs. See the Appendix for a full list.

`CommonWords` has functions to remove common words from sentences, and to strip trailing punctuation characters from single words (this is important in question processing; there is always a "?" in a question, but it is never part of a keyword).

3.3.4 Stemmer

The stemmer is an implementation of the Porter stemmer[2] in Ruby by Ray Pereda. The module Stemmable includes itself in the String class, so strings can call the function stem. The calling string is stemmed then returned.

3.3.5 Inflector

The Inflector module is taken from the Active Support package (part of Ruby on Rails). It contains (in `inflections.rb`) a variety of hard-coded rules for pluralizing English words; we use this in the answering component, when substituting the article title for the pronoun "they". See the Appendix for details.

4 Future Work

The most significant aspect of the problem we struggled with was asking more difficult questions. We had implementations in place to ask both medium difficulty and hard questions, but ultimately removed them from our solution due to coherency problems. These modules actually did make use of the ideas in our initial plan; the medium difficulty questions were generated by extracting named entities and adding "what is" or "who is" to them based on the categories to form questions. The hard questions used a classifier to determine which of the three article categories the given article belonged to and asked a series of hard coded questions based on the category. If we had more time to deal with the coherency problems, both would have been nice to include.

Our question asking solution was quite extensible, with its structure of delegating the finding of good sentences and transforming them into answers to the various "Matcher" components. We had some ideas for other matchers; for example, one much like `FactoidMatcher` except that it would replace NPs other than the subject NP with wh-words. We did not have time to implement these other ideas.

An area we didn't explore and that would be significantly more work would be implementing the question answering system that takes over when `EasyAnswer` fails. `EasyAnswer` returns no answer if the best match sentence contains fewer than half of the keywords, so there would be a need for a more advanced answerer that deals with this case. Since our results were generally so good, we didn't go in that direction, but it's a significant enough problem that if this solution were to be released it would need to be dealt with.

[2] `http://tartarus.org/~martin/PorterStemmer/`

Appendix

Common words

```
DETERMINERS = ['a', 'an', 'the', 'this', 'that', 'these', 'those']
AUXILIARIES = ['be', 'am', 'is', 'are', 'were', 'was', 'been',
               'do', 'does', 'did']
WHWORDS = ['what', 'which', 'how', 'when', 'where', 'why', 'who']
MODALS = ['will', 'can', 'may', 'might', 'would', 'should']
PREPOSITIONS = ['of', 'in', 'for', 'with', 'at', 'from', 'to', 'as',
  'within', 'between', 'there', 'on', 'by']
OTHERS = ['and', 'or', 'it', 'many', 'much']

PUNCTUATION = ['?', '!', ',', '.', "'"]

COMMONWORDS = [DETERMINERS, AUXILIARIES, WHWORDS, MODALS, PREPOSITIONS,
  OTHERS]
```

Pluralization

Each line adds a rule; input words are matched against the regex in the first argument and, if they match, undergo the substitution in the second argument. Words are matched starting with the last rule added.

```
inflect.plural(/$/, 's')
inflect.plural(/s$/i, 's')
inflect.plural(/(ax|test)is$/i, '\1es')
inflect.plural(/(octop|vir)us$/i, '\1i')
inflect.plural(/(alias|status)$/i, '\1es')
inflect.plural(/(bu)s$/i, '\1ses')
inflect.plural(/(buffal|tomat)o$/i, '\1oes')
inflect.plural(/([ti])um$/i, '\1a')
inflect.plural(/sis$/i, 'ses')
inflect.plural(/(?:([^f])fe|([lr])f)$/i, '\1\2ves')
inflect.plural(/(hive)$/i, '\1s')
inflect.plural(/([^aeiouy]|qu)y$/i, '\1ies')
inflect.plural(/([^aeiouy]|qu)ies$/i, '\1y')
inflect.plural(/(x|ch|ss|sh)$/i, '\1es')
inflect.plural(/(matr|vert|ind)ix|ex$/i, '\1ices')
inflect.plural(/([m|l])ouse$/i, '\1ice')
inflect.plural(/^(ox)$/i, '\1en')
inflect.plural(/(quiz)$/i, '\1zes')
```