SAT Critical Reading Solver

1.1 Executive Summary

The SAT (prev. Scholastic Aptitude Test) is a nationwide test given to graduating high school students in the United States of America as a means of determining likelihood of success in college and university. The SAT is composed of three sections, one of which is titled The critical reading section. The critical reading section provides test-takers with two forms of questions: sentence completion and paragraph style questions. In sentence completion questions, a sentence with blanks is provided to the test-taker, as well as five options to choose from to fill the blanks in the most grammatical and sensibly correct pattern. In paragraph style questions, the test-taker is given a paragraph to read and a set of questions regarding inferences and relationships of the piece.

As a means of exploratory work in Natural Language Processing, the SAT Critical Reading Solver is a computational approach to correctly solving SAT critical reading problems. The Solver will tackle both sentence completion and paragraph style questions in an attempt to accurately identify the correct multiple-choice answer.

sentence completion questions will be solved using dictionary knowledge bases as well as a clustering machine learning approach on training sentence completion datasets.

Paragraph style questions are intended to be self contained. The Solver will construct relationship graphs between entities in the paragraph and will be trained on training SAT data sets to make an attempt to recognize styles of questions. When the style of a question is determined, the Solver will assign a score to each multiple choice answer depending on the links in the relationship graph.

Deliverables:
1. A list of knowledge bases and training SAT tests (with answer keys)
2. A test SAT set (with answer keys) that has not been used in any training
3. A python software package that reads in a particular SAT critical reading section and produces an answer key that can be evaluated

1.2 Goal

The SAT Critical Reading Solver will make an attempt to earn a higher score than the national average of 500/800 possible points. The Solver use previous SAT tests and various knowledge bases as training data and will be capable of producing answers for both formats of questions presented in the critical reading section of the SAT with a relatively high accuracy. Not only will the SAT Critical Reading Solver present validity of a computational approach to entry-college test taking, but it will also serve as a research tool to further advance new test writing.

1.3 Background & Motivation

The SAT test is an old test and is one that, like other college entrance exams, causes extreme stress for high school students. Natural Language Processing has been applied in some form to various examinations globally, but has not been applied directly to SAT critical reading. In the SAT Critical Reading Solver, we will make an attempt to convince test-takers that using the model of previous tests, a relatively high score can be obtained. In a similar manner that IBM Watson was used in the popular game show jeopardy to demonstrate some of the latest natural language processing research, the SAT Critical Reading Solver will prove that such methods can be applied to

Current approaches to examination solvers include the use of explicit semantic analysis based similarity, skip-gram modelling, and latent semantic analysis. For example, researchers at the Allen Institute for Artificial Intelligence have implemented a solver that can answer SAT geometry questions with an accuracy of 49%. This solver achieves this rate by combining traditional NLP techniques, such as semantic parsing and relation extraction, with diagram parsing.

1.4 System Architecture & Approach

The SAT Critical Reading solver will include two parts a sentence completion solver and a system that answers passage based reading questions.

The first step in solving sentence completion question requires identifying keywords and relationship between the words and the missing blank. As part of the preprocessing process, PoS, entity tagging and chunking will identify these words and relationships. Word2Vec will be used to extract feature vectors and and determine the similarities between between words. In order to enhance the corpus, Word2Vec will be set to train on a thesaurus which will allow for a more advanced lexicon.

For the passage based reading question a variety of approaches are going be used including named heterogeneous graph based approach, dependency parsing and entity/relationship extraction. A sentence retrieval phase will be used to identify sentences in the passage that are directly relevant to the question at hand.

Both of these solvers will use a regression to rank the multiple choice answers and will choose the best answer if the likelihood exceeds a certain threshold.

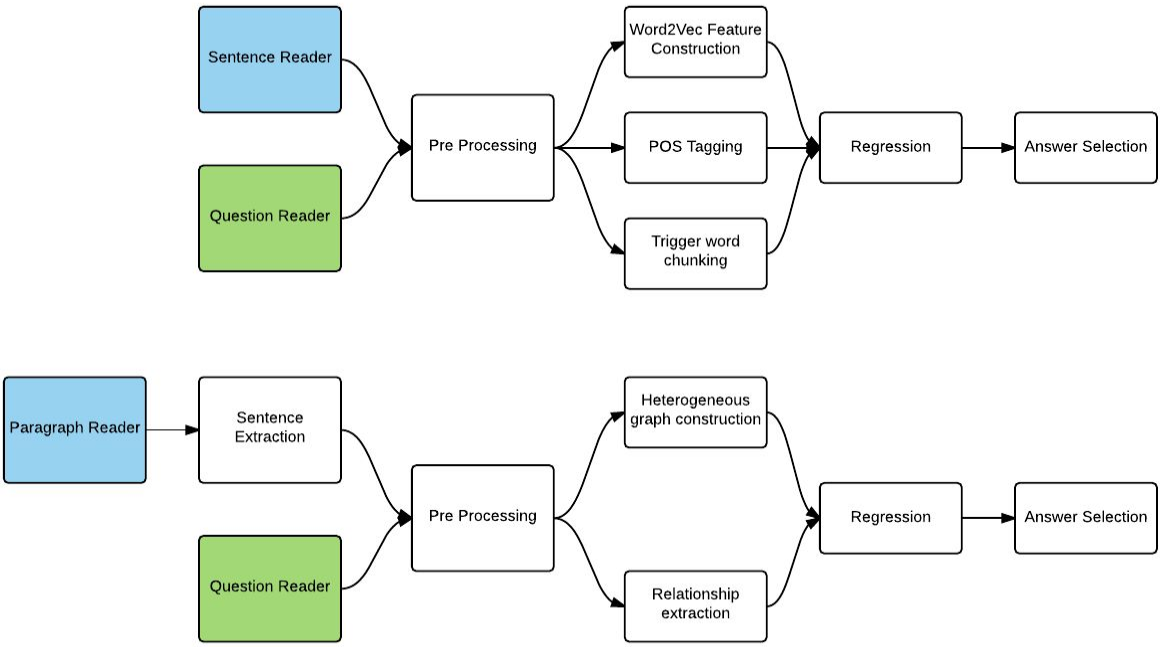

Figure 1: Sentence Completion and Passage-Based Learning System

1.5 Deliverables

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1.6 Team Organization

Raymond Jacobson, CS/CSE '16, has taken Machine Learning and is currently enrolled in Data Mining and Natural Language Processing.

Akshay Mata, CS/EE '16, has taken Machine Learning and is currently enrolled in Natural Language Processing.

Raymond and Akshay will share the responsibility detailing procedures, but Raymond will focus his attention to Graph based methods and feature extraction and Akshay will tailor his focus to knowledge base mining and regression. Both will begin the project by solving the sentence completion style questions first. Most work on the project will be produced via a pair coding collaboration style.

1.7 Required Resources

1. Sample SAT sections/questions and answer keys (team will provide)
2. Latest attempts at examination solvers from EU and China (provided by instructor)

1.8 Time Table

November 4, 2015: Write system architecture and learning/evaluation framework to assign an equal score to each possible answer in an SAT critical reading section and randomly select outcome. This iteration will provide a baseline for future work (Answering on average 1/5th of questions correctly).

November 11, 2015: Being implementation of sentence completion solver

November 18, 2015: Finish implementation of sentence completion solver

November 25, 2015: Begin construction of entity relationship graph from paragraph style questions

December 2, 2015: Apply machine learning techniques and relationship examination to ER graph

December 9, 2015: Retrain and taylor solver

1.9 Resources

http://www.aclweb.org/anthology/I13-1192

http://www.washington.edu/news/2015/09/21/ai-system-solves-sat-geometry-questions-as-well-as-average-human-test-taker/

http://allenai.org/

http://icce2014.jaist.ac.jp/icce2014/wp-content/uploads/2014/12/ICCE2014DIpaper.pdf

http://geometry.allenai.org/assets/emnlp2015.pdf

https://www.aaai.org/ocs/index.php/FLAIRS/FLAIRS11/paper/viewFile/2645/3033

http://www.eecs.harvard.edu/~shnayder/papers/ranlp03-analogy.pdf

http://www.datascienceassn.org/sites/default/files/Solving%20Verbal%20Comprehension%20Questions%20in%20IQ%20Test%20by%20Knowledge-Powered%20Word%20Embedding.pdf