

BSc AI Thesis - Project Plan

Title: Solving math word problems with controlled language

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Literature review

Since the invention of the calculator, computers do an excellent job in calculating math expressions. The language for expressions is machine-understandable such that a system could perform calculations. Typically, however, the language used to describe math problems is a substrate of natural language (NL), which, although it relies on technical terms and grammatical conventions, is not machine-understandable. A controlled natural language (CNL) is a subset of NL that is human and machine-understandable. But, when math is expanded to NL computers have a hard time understanding it. A controlled natural language for mathematics (CLM) is developed [1] to solve this. This CLM is used as a step towards automatic formalisation and verification of textbook mathematical text. However, the coverage of CLM facilitates common reasoning patterns but is limited. The task of converting NL to First-Order Logic (FOL) remains an area of research. Direct approaches have been tried. Neural models showed difficulties in modelling NL to FOL [2]. The use of CNL could help form a bridge in this task. Research supports this approach wherein simplified English texts are converted from NL to Logic using CNL as an intermediate step [3]. Natural Language Processing (NLP) techniques make this conversion from NL to CNL possible. Further research supports this, wherein the conversion of legal text to CNL is attempted using NLP techniques [4]. To this day, simple middle school word math problems are difficult to solve for a computer. Attempts have been made by using autoregressive language models like GPT-3 [5]. A significant amount of research is focussing on converting NL straight into logic. Unfortunately, the results are still unsatisfiable. To tackle this, targeting primarily a conversion of NL to CNL might improve performance in this task [6]. Because CNL has a direct logical interpretation, it allows solving simple math problems given in textual form by using logic. Therefore, the core step of this method is the machine translation task from NL to CNL. The task requires a CL that is suited for making calculations. Attempto Controlled English (ACE) is a possible CL that is able to make this conversion [7]. It has a countable property and thus could be used to derive simple calculations.

Research question

The task of solving simple math word problems using computers remains unsolved. The conversion from NL to CNL seems a promising approach to tackle this task. This is because CNL has a direct logical interpretation, at which calculations could be done. Hence, can simple math word problems be solved by utilizing a CNL?

Method and approach

First, literature research will be done to explore the subject and possible approaches. Then a proof-of-concept of the system pipeline will be pursued. The pipeline consists of two parts. One, the machine translation from NL to CNL. Two, the ACE parser to calculation. Once the proof-of-concept is realised, the focus will shift towards a unifying system. This system will convert NL to calculation using the pipeline. This may require the identification and or generation of training data. A cycle of experiments will be performed on the machine translation module. Experiments will be evaluated, reported and finetuned.

Evaluation

APE will be used as a validator for CL. In this way, text converted from NL to CL will be evaluated. The respective answers to the word problems are fixed and known. Thus, these answers will be used to evaluate the calculated answers.

Plan

Gantt-chart at end of the file.

Report and presentations

The report will be written throughout the project. Towards the end of the project, more time will be assigned to this task. For this 2/3 weeks are in mind at the moment. Time is also set aside for preparing presentations, this will be 3 days. The choice on how to carry out the presentation is open. This can be either physical or through a pre-recorded video.

Bibliography

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- [7] Fuchs, N. E., & Schwitter, R. (1996). Attempto controlled english (ace). *arXiv preprint cmp-lg/9603003*.

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