Math Bot

Equation Generation from Elementary Math Word Problem

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Problem Statement

- **Aim:** Our aim is to build a model which is capable of generating equation given elementary math word problems.
- **Input:** Elementary Math Word Problem.
  Output: Single Variable Equation.

Basic Papers

- Translating a Math Word Problem to a Expression Tree- https://www.aclweb.org/anthology/D18-1132.pdf.
- A Goal-Driven Tree-Structured Neural Model for Math Word Problems- https://www.ijcai.org/Proceedings/2019/0736.pdf

Data

- **DataSets** (Draw1K, Dolphin18K (https://www.microsoft.com/en-us/research/wp-content/uploads/2015/08/dolphin18k.pdf), ALG514, Math23k(Translated to English) (https://raw.githubusercontent.com/ShichaoSun/math_seq2tree/master/data/Math_23K.json)).
- We extracted subset of examples from all the datasets, that contain a single unknown.
- After Data Prepossessing we got around 25K data points.

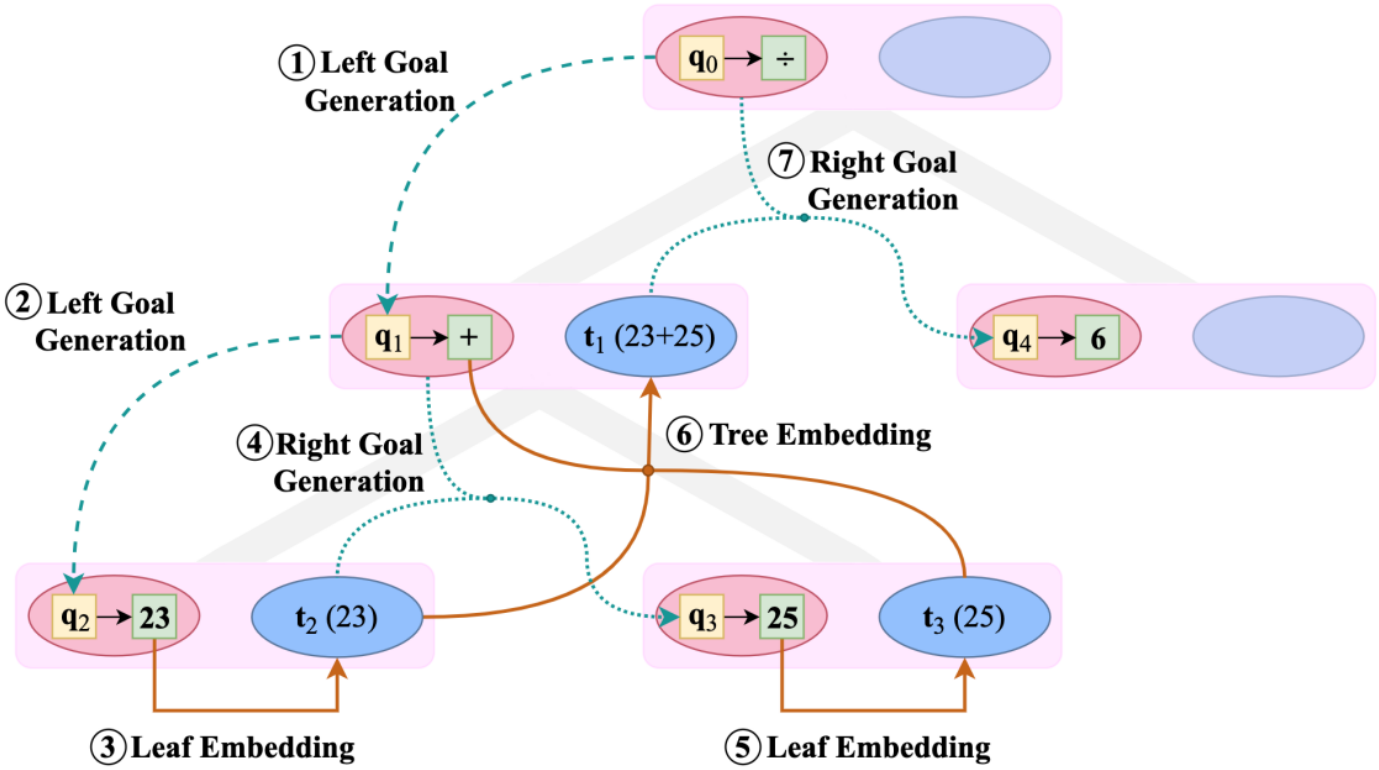
Data Preparation

- We processed each problem/question by replacing every number by variable n0, n1...etc in the order left to right.
- And for the gold equation, first we converted every number into its corresponding variable(n0,n1,etc) from problem. Then we converted this equation into prefix notation.
- We applied this same pre-processing step to all the datasets collected(mentioned before).

Techniques used

- Encoder-Decoder Architecture(Baseline) (Encoder:-GRU, Decoder:-LSTM).
- We used Transformer Architecture 4 layers as second architecture.
- Encoder-Decoder Architecture (Encoder:-BiGRU, Decoder:-Goal Driven Tree Structured Neural Model). Example of the decoder is given in the next slide.

Techniques Used (Cont.)



Results

Model	Solution Accuracy
Encoder-Decoder	10.2 %
Transformer	54.2 %
Goal-Driven Tree-Structured Neural Model	71.6 %

Results

We trained the models on both infix equations and prefix equations and calculated answer accuracy on test data.

Model	Infix equations accuracy	Prefix equation accuray
Encoder-Decoder	9.7 %	10.2 %
Transformer	48.75 %	54.2 %
Goal-Driven Tree-Structured Neural Model	65%	71.6 %

Demo and Case Study

- **Input:** The second-year children of Zhenhai Yale School went to the side of a small road to plant trees. The children planted a tree every 2 meters (trees were planted at both ends of the road), and finally found that a total of 11 trees were planted. How many meters is the path long?

  Output Equation: x=(11-1)*2. **Output Answer:** 20
- **Input:** 15 children were playing hide-and-seek, 4 of them have been caught, and how many others have not been caught?

  Output Equation: x=15-4 **Output Answer:** 11

Conclusion and Future Work

Conclusion: Goal-Tree structure method beat the transformer model with a huge margin in solution accuracy.
Future Work: We can make a mobile app in which anybody can scan the math word problem and our algorithm will give the equation and answer to it.

References

- Xie, Zhipeng, and Shichao Sun. "A Goal-Driven Tree-Structured Neural Model for Math Word Problems." In IJCAI, pp. 5299-5305. 2019.
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- Huang, Danqing, Shuming Shi, Chin-Yew Lin, Jian Yin, and Wei-Ying Ma. "How well do computers solve math word problems? large-scale dataset construction and evaluation." In Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers), pp. 887-896. 2016.