WALGES: Weighted Probability Based Scoring Approach for Solving Algebraic Word Problems using Semantic Parsing

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RESEARCH OBJECTIVE

To acheive higher accuracy in solving arithmetic word problems by semantic parsing and reasoning.

INTRODUCTION

Verbally expressed addition, subtraction, multiplication, and division problems are the algebraic word problem. An example of the algebraic word problem is shown in the Fig. 1:

Melanie had 19 dimes in her bank. Her dad gave her 39 dimes and her mother gave her 25 dimes. How many dimes does Melanie have now?

Figure 1: Algebraic Word Problem (Addition)

Figure 2: Example of Semantic Representation

PROPOSED METHODOLOGY

Mike had 34 peaches left at his roadside fruit stand. He went to the orchard and picked more peaches to stock up the stand. There are now 86 peaches at the stand, how many did he pick?

Figure 5: Algebraic World Problem (Subtraction)

quantities : 34 86 x
types : “peach" “peach" “stand"

Figure 6: Example of Grounding based on Fig. 5

$T_1(w)$: subset of $T(w)$ yielding correct solution

Figure 7: Example of generated equation trees based on Fig. 6

Qsets	Operator
$(86_d, 34_d)$	–
$(34_d, 86_d)$	–

Figure 8: Example of training local model Fig. 7

Training Example	Label
$x = (86 - 34)$	+ve
$(34 - 86) = x$	-ve

Figure 9: Example of Global Equation Model

EXPERIMENTAL DATASET

Grade school algebraic word problems of single equation was used in this work. Dataset was used in ALGES [1] named as **SINGLEEQ**. Problems and their solutions were collected from *http://math-aid.com*, *http://k5learning.com*, and *http://ixl.com*. 508 problems in total, 1,117 sentences, and 15,292 words was in the dataset. Addition, Subtraction, Multiplication and Division word problems were equally present in SINGLEEQ.

RESULT

WALGES Equation:

$$p(t|w) \propto ((\alpha \times \prod_{t_j \in t} \mathcal{L}_{local}(t_j|w)) + (\beta \times \mathcal{G}_{global}(t|w))) \quad (1)$$

ALGES [1] Equation:

$$p(t|w) \propto (\prod_{t_j \in t} \mathcal{L}_{local}(t_j|w) \times \mathcal{G}_{global}(t|w)) \quad (2)$$

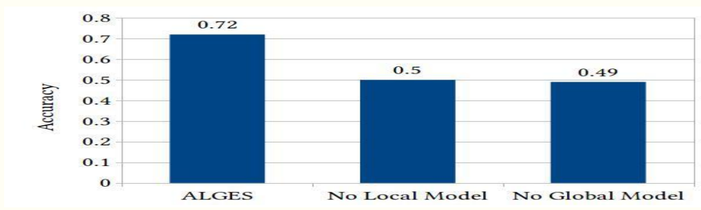

Figure 3: Ablation Study of ALGES [1]

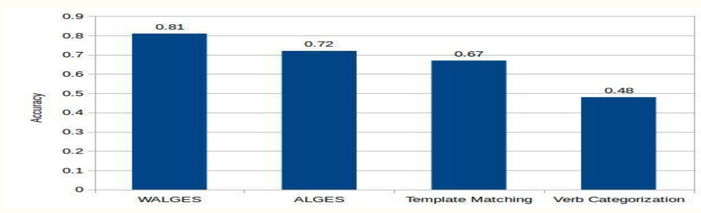

Figure 4: Performance Comparison

Table 1: Performance comparison on Subsets of **SINGLEEQ**

System	508	254	127	63
WALGES	**0.81**	**0.66**	0.52	0.30
ALGES	0.72	**0.66**	**0.66**	**0.63**
Template-based	0.67	0.60	0.46	0.26
Verb Categorization	0.48	0.42	0.37	0.31

CONCLUSION AND FUTURE WORK

Neural network algorithm is used to generate the solution. By weighted probability based scoring, our proposed system WALGES fixes more error.
Future work will focus on solving multivariable problems and extend to ground the voice input.

REFERENCES

[1] Rik Koncel-Kedziorski, Hannaneh Hajishirzi, Ashish Sabharwal, Oren Etzioni, and Siena Dumas Ang, “Parsing algebraic word problems into equations,” in Transactions of the Association for Computational Linguistics, vol. 3, pp. 585–597, 2015.