

Towards Generating Math Word Problems from Equations and Topics: Supplementary Material

Abstract

This note contains supplementary materials to *Towards Generating Math Word Problems from Equations and Topics*.

A Human Evaluation Guideline

In this section, we describe the guidelines we show to the annotators for the evaluation.

We ask the annotators to score 1 to 3 given the outputs of different models from four aspects:

1. Equation Relevance: the generated problem is relevant to the given equation (Table 1);
2. Topic Relevance: the generated problem is relevant to the given topic words (Table 2);
3. Solvability: the generated problem is comprehensible and can be solved by an equation (Table 3);
4. Language Fluency: the generated problem is grammatical and fluent (Table 4).

B Qualitative Example

We show several math problem outputs of different systems for comparison in Table 5.

Problems generated by MAGNET are more relevant to both the equation template and the topics. For example, in case 1, the Equ2Math output ignores the topic word “sum”, while the Topic2Math output does not satisfy the number requirement in the equation template. While compared, MAGNET generates the problem asking “sum of the series” that is highly related to the topic words; and can be further solved by the given equation template.

C Error Analysis

Table 6 shows examples of two main types of errors by our model: (1) Problem soundness. The generated problem lacks semantic coherence. The first problem in Table 6 contains “plants [num0] feet of fence to build a fence” that is non-comprehensive, and the following “the width of the pen” that is semantically incoherent with the previous description; (2) Equation matchness.. The equation template is partially correlated to the output, but not an exact solution of it. For example, the solution of the second example problem should be $[num0] * m = [num1]$, which is different from the input equation template. This is somewhat expected, since we use the entity-enforced loss only as a soft constraint to ensure the relevance of equation and generated problem. We leave the challenge of exact equation match to the future work.

Score	Description	Example: $x + y = [num0], x - y = [num1]$
1	The problem is not relevant to the equation at all.	“What is $[num0]$ divided by $[num1]$?”
2	The problem is somehow relevant to the equation, (e.g., part of the equation match the problem).	“What are two numbers if their sum is $[num0]$ and their product $[num1]$?”
3	The problem exactly matches the equation.	“What are two numbers if their sum is $[num0]$ and their difference $[num1]$?”

Table 1: Criterion for scoring equation relevance.

Score	Description	Example: {shirt, sell, discount}
1	The problem is not relevant to the topic words at all.	“What is $[num0]$ divided by $[num1]$?”
2	The problem is somehow relevant to the topic words.	“A cup costs $[num0]$ dollars. How much does it cost with a $[num1]$ discount?”
3	The problem is very relevant to the topic words.	“A shirt costs $[num0]$ dollars. How much does it cost with a $[num1]$ discount?”

Table 2: Criterion for scoring topic relevance.

Score	Description	Example: $x + y = [num0], x - y = [num1]$
1	The problem is not valid that cannot solved by an equation.	“What does $[num0]$ cost for the shop?”
2	The problem can be solved by an equation but not the given equation.	“What are two numbers if their sum is $[num0]$ and their product $[num1]$?”
3	The problem can be solved by the given equation.	“What are two numbers if their sum is $[num0]$ and their difference $[num1]$?”

Table 3: Criterion for scoring solvability.

Score	Description	Example:
1	The problem is grammatically wrong.	“What is $[num0]$ by divided for such such number? ”
2	The problem is fluent with no obvious grammatical mistakes.	“What are two numbers what what if their sum is $[num0]$ and their difference $[num1]$?”
3	The problem is readable with some minor grammatical errors.	“What are two numbers numbers if their sum are $[num0]$ and their product $[num1]$?”

Table 4: Criterion for scoring language fluency.

<p>Case 1</p> <p>Equation Template: $[num0] + [num1] + [num2] + [num3] = m$</p> <p>Topic words: geometric, series, sum, find</p> <p>KNN: there are [num0] geometric series with sum to [num1] of [num2] and second term of [num3] . find 1st term ratio of both .</p> <p>Equ2Math: what is the next number in the sequence ? [num0] , [num1] , [num2] , [num3] , ? ? ?</p> <p>Topic2Math: the sum of the series of [num0] terms is [num1] . if the sum of the series is [num2] , find the sum of the series</p> <p>MAGNET-Entity: find the sum of the series geometric , [num0] , [num1] , [num2] , and [num3] .</p> <p>MAGNET: find the sum of the series below , [num0] , [num1] , [num2] , [num3] , .</p> <p>Ground truth: find the sum of geometric series [num0] , [num1] , [num2] , [num3]</p>
<p>Case 2</p> <p>Equation Template: $m = [num0] * (1 + [num1])$</p> <p>Topic words: sweater anna priced tax pay sales bought much percent</p> <p>KNN: at a rate if [num0] percent what is the sales tax on a car priced at [num1] ?</p> <p>Equ2Math: the price of a desktop computer is [num0] \$. the sales tax rate is [num1] percent . what is the total cost of the computer ? options : [num2] \$ [num3] \$ [num4] \$ [num5] \$</p> <p>Topic2Math: in a sweater , she bought [num0] \$ for a sweater . [num1] percent of the tax was priced at [num2] percent . how much is the sales tax ?</p> <p>MAGNET-Entity: susan bought a sweater that was priced at [num0] \$. if she priced at [num1] percent , how much was the original price ?</p> <p>MAGNET: if anna bought a sweater for [num0] \$, the sales tax is [num1] percent . how much is the sales tax ?</p> <p>Ground truth: anna bought a sweater priced at [num0] \$ and the sales tax was [num1] percent . how much did she pay for the sweater ?</p>
<p>Case 3</p> <p>Equation Template: $[num0] * m + [num1] * n = [num3] * [num2]; m + n = [num2]$</p> <p>Topic words: coffee pound per roast vanilla fresh blend type sells used</p> <p>KNN: what is [num0] of [num1] ?</p> <p>Equ2Math: how many pound of almonds selling at [num0] \$ a pound must mixed with peanuts selling for [num1] \$ a pound to make a mixture of [num2] pound for [num3] \$ a pound ?</p> <p>Topic2Math: a grocery store sells a mixture of [num0] \$ per pound and sells for [num1] \$ per pound . how many pound of each type of cream should be used to make [num2] pound of a blend that sells for [num3] \$ per pound ?</p> <p>MAGNET-Entity: soybean meal is [num0] \$ per pound . continental mocha sells [num1] pound per pound . how much of each type should be used to make a [num2] pound mixture that sells for [num3] \$ per pound ?</p> <p>MAGNET: kim 's coffee beans that sells for [num0] \$ per pound and <i>unk</i> sells for [num1] \$ per pound . how many pound of each type of coffee should be used to make [num2] pound of a blend that sells for [num3] \$ a pound ?</p> <p>Ground truth: starbucks chatges [num0] \$ per pound for fresh roast coffee and [num1] \$ per pound for vanilla coffee . how much of each type should be used to make a [num2] pound blend that sells for [num3] \$ per pound ?</p>
<p>Case 4</p> <p>Equation Template: $[num0] * m + [num1] = [num2]$</p> <p>Topic words: thinking multiply add get will number</p> <p>KNN: i am thinking of a number . if i add [num0] , multiply the result by [num1] and then subtract [num2] , i get [num3] . what is my number ?</p> <p>Equ2Math: the sum of [num0] times a number and [num1] is [num2] . what is the number ?</p> <p>Topic2Math: i am thinking of a number . if you add [num0] and add [num1] , you get [num2] . what will be the number ?</p> <p>MAGNET-Entity: i am thinking of a number . i multiply it by [num0] and add [num1] . i get the same number of number , you will be [num2] . what number is clarence thinking of ?</p> <p>MAGNET: i am thinking of a number . if i multiply it by [num0] , add [num1] , i get [num2] . what is my number ?</p> <p>Ground truth: i 'm thinking of a number if you multiply it by [num0] and then add [num1] you will get [num2] . what is it ?</p>

Table 5: Examples of generated math word problems.

Error 1: Problem soundness

Equation Template:

$$[num2] * (m + n) = [num3], [num2] * m + [num1] = n$$

Topic words:

pen owns feet dogs build farmer fence size use width

Output: a farmer plants [num0] feet of fence to build a fence. the width of the fence is [num1] feet more than [num2] times the width . find the width of the fence and **the width of the pen?**

Error 2: Equation exact match

Equation Template:

$$m * n = [num1], m = n + [num0]$$

Topic words:

field width yard rectangular area length find

Output: the length of a rectangular field is [num0] yard . the area is [num1] yard . find the length and width .

Table 6: Two main types of errors observed in our model.