

Introduction

Logical reasoning requires to correctly infer the semantic relations with respect to the constituents among different sentences. As shown in the right, to find the correct answer for the given question, one needs to extract the logical structures residing in a pair of each option and the whole context, and justify its reasonableness.

Although the pretrained language models have achieved significant progress on several benchmarks, they still struggle on inferring the logical relations beneath natural language since the goal of general pre-training, i.e., masked language modeling, deviates largely from that of logical reasoning.

In this paper, we present MERIt, a MEta-path guided contrastive learning approach for logical Reasoning of text. To the best of our knowledge, we are the first to explore self-supervised pre-training for logical reasoning.

Method

Q1: How to discover the logical structure in a raw document?

A1: The logical reasoning process can be formulated as:

$$\langle v_i, r_{i,j}, v_j \rangle \leftarrow (v_i \xrightarrow{r_{i,i+1}} v_{i+1} \xrightarrow{r_{i+1,i+2}} \dots \xrightarrow{r_{j-1,j}} v_j) \quad (1)$$

Take entity e_i as the logical variable v_i :

$$\langle e_i, r_{i,j}, e_j \rangle \leftarrow (e_i \xrightarrow{r_{i,i+1}} e_{i+1} \xrightarrow{r_{i+1,i+2}} \dots \xrightarrow{r_{j-1,j}} e_j) \quad (2)$$

The right part is a meta-path connecting $\langle e_i, e_j \rangle$ through indirect relations, while the left part is a direct relation triplet. We then employ Eqn.2 to discover the logical structure in a document.

Q2: How to construct logically consistent instance pair?

A2: We assume the pair defined in Eqn. 2 is logically consistent under the same context, following which we construct the positive context-option pair. An example is shown in Fig. 2 (a) and (b).

Context: Economist: (1) A country's rapid emergence from an economic recession (r_1) requires (2) substantial new investment in that country's economy. Since (3) people's confidence in the economic policies of their country (r_2) is a precondition for (2) any new investment, (4) countries that put collective goals before individuals' goals (r_3) cannot (1) emerge quickly from an economic recession.

Question:

Which one of the following, if assumed, enables the economist's conclusion to be properly drawn?

Options:

A. People in (4) countries that put collective goals before individuals' goals (r_4) lack (3) confidence in the economic policies of their countries.

B. A country's economic policies are the most significant factor determining whether that country's economy will experience a recession.

C. If the people in a country that puts individuals' goals first are willing to make new investments in their country's economy, their country will emerge quickly from an economic recession.

D. No new investment occurs in any country that does not emerge quickly from an economic recession.

Answer: A

Logic Structure: (4) $\xrightarrow{r_4}$ (3) $\xrightarrow{r_2}$ (2) $\xrightarrow{r_1}$ (1) \Leftrightarrow (4) $\xrightarrow{r_3}$ (1)

Fig. 1: An example of logical reasoning from ReClor.

Q3: How to generate negative instances?

A3: We generate the negative instances through the modification of the relations in the positive instance pair, which is further implemented via entity replacement as shown in Fig. 2 (c).

Q4: Is there any possible trivial solutions during the contrastive learning process?

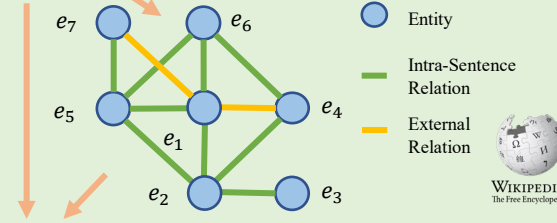
A4: Yes. The commonsense knowledge entailed in the pre-trained language models may lead to trivial solutions by simply checking the factuality of each option.

Q5: How to eliminate the shortcut?

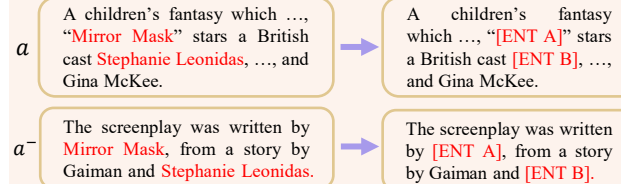
A5: We devise a counterfactual data augmentation strategy by replacing the original entities with those from different documents (Fig. 2 (d)).

(a) Graph Construction

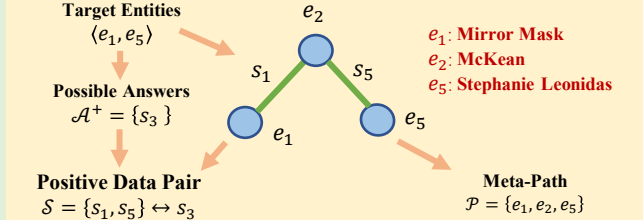
(s_1) "Mirror Mask (e_1)", McKean (e_2)'s first feature film as director, premiered at ... in January 2005. (s_2) The screenplay was written by Neil Gaiman (e_3), from a story by Gaiman and McKean. (s_3) A children's fantasy ..., "Mirror Mask" was produced by Jim Henson Studios (e_4) and stars a British cast Stephanie Leonidas (e_5), ... and Gina McKee (e_6). (s_4) Before "Mirror Mask", McKean directed a number of ... (s_5) McKean has directed "The Gospel of Us (e_7)", ... A new feature film, "Luna", written and directed by McKean and starring Stephanie Leonidas, ..., debuted at



(d) Counterfactual Data Augmentation



(b) Meta-Path Guided Positive Instance Construction



(c) Negative Candidate Generation

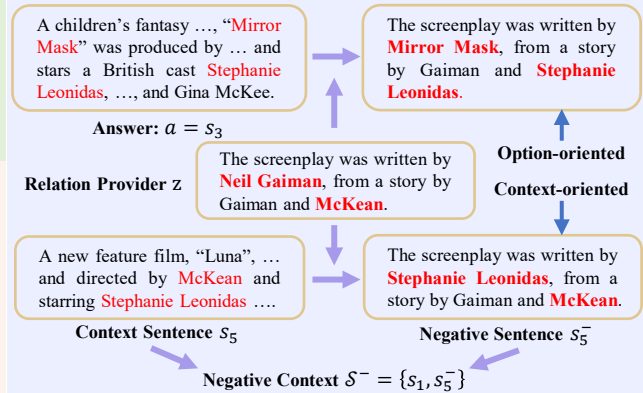


Fig. 2: The data construction process of our method.

Experiment

Model / Dataset	ReClor				LogiQA	
	Dev	Test	Test-E	Test-H	Dev	Test
RoBERTa	62.6	55.6	75.5	40.0	35.0	35.3
DAGN	65.2	58.2	76.1	44.1	35.5	38.7
DAGN (Aug)	65.8	58.3	75.9	44.5	36.9	39.3
LReasoner (RoBERTa) [†]	64.7	58.3	77.6	43.1	—	—
Focal Reasoner	66.8	58.9	77.1	44.6	41.0	40.3
MERIt	66.8	59.6	78.1	45.2	40.0	38.9
MERIt + LReasoner	67.4	60.4	78.5	46.2	—	—
MERIt + Prompt	69.4	61.6	79.3	47.8	39.9	40.7
MERIt + Prompt + LReasoner	67.3	61.4	79.8	46.9	—	—
ALBERT	69.1	66.5	76.7	58.4	38.9	37.6
MERIt (ALBERT)	74.2	70.1	81.6	61.0	43.7	42.5
MERIt (ALBERT) + Prompt	74.7	70.5	82.5	61.1	46.1	41.7
<i>max</i>						
LReasoner (RoBERTa)	66.2	62.4	81.4	47.5	38.1	40.6
MERIt	67.8	60.7	79.6	45.9	42.4	41.5
MERIt + Prompt	70.2	62.6	80.5	48.5	39.5	42.4
LReasoner (ALBERT)	73.2	70.7	81.1	62.5	41.6	41.2
MERIt (ALBERT)	73.2	71.1	83.6	61.3	43.9	45.3
MERIt (ALBERT) + Prompt	75.0	72.2	82.5	64.1	45.8	43.8

Tab. 1: The accuracy of different models on ReClor and LogiQA. We use RoBERTa-large and ALBERT-xxlarge as the backbone.

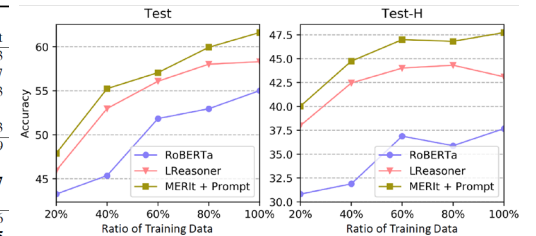


Fig. 3: The results on the test set and test-H set of ReClor.

Model	Dev	Test	Test-E	Test-H
DeBERTa-v2-xxlarge	76.7	71.0	83.8	60.9
+ MERIt	78.0	73.1	86.2	64.4
DeBERTa-v2-xxlarge	78.3	75.3	84.0	68.4
+ MERIt	80.6	78.1	84.6	72.9

Tab. 1: The results on ReClor with DeBERTa as the backbone.