Question Generation of Reading Comprehension of Language Learning Test

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Background

- Generation of reading comprehension questions is an important & practical research

  - Examination of language learning
    - Examinees need reading questions for exercises
    - Making reading questions is a huge work for examiners

  - Training & Test for QA researches

Purpose

- Generate the questions that could be used for reading comprehension of language learning test from given articles

  - <u>Generate the description of the questions</u>

  - Prepare the answer options

Contributions

- Find out the *Relevant Sentences* of a posed question from the given article.

- Proposed a method using seq2seq model to generate several different questions from single input article.

- Proposed method could generate DR & CM questions.
  - DR: content-based question
  - CM: common sense question

Reading Comprehension

Many years ago, when I was fresh out of school and working in Denver, I was driving to my parents' home in Missouri for Christmas. I stopped at a gas station about 50 miles from Oklahoma City, where I was planning to stop and visit a friend. While _____ to an older couple who were also paying for gas. I took off, _____ ured from the back of my car. I stopped and wondered what _____ **Given Article** _____ ouple I had spoken to at the gas station. They said they wo _____ nto the city, and when I got out of the car, the husband ga _____ hank-you note for helping me. Soon afterward, I received a Christmas present from them. Their note that came with it said that helping me had made their holidays meaningful. Years later, I drove to a meeting in a nearby town in the morning. In late afternoon I returned to my car and found that I'd left the lights on all day, and the battery was dead.

Questions:
1. **The author planned to stop at Oklahoma City _ .**
   A. to visit a friend B. to see _____ more gas for his car
2. **What happened when the** _____
   A. He had it pulled back to t ____ **QUESTIONS** ____ rd.
   C. The couple offered to he _____
3. **The battery of the author's** _____
   A. something went wrong with the lights B. the meeting lasted a whole day
   C. he forgot to turn off the lights D. he drove too long a distance

The author planned to stop at Oklahoma City _ . What happened when the author found smoke coming out of his car? The battery of the author's car was dead because _ .

- Correspondence of each question & the relevant sentences is not clear.

Expected Sentences-Question Pair

Many years ago, when I was fresh out of school and working in Denver, I was driving to my parents' home in Missouri for Christmas. I stopped at a gas station about 50 miles from Oklahoma City, where I was planning to stop and visit a friend.	The author planned to stop at Oklahoma City __ .
While I was standing in line at the cash register, I said hello to an older couple who were also paying for gas. I took off, but had gone only a few miles when black smoke poured from the back of my car. I stopped and wondered what I should do. A car pulled up behind me. It was the couple I had spoken to at the gas station. The ~~Given Article~~ chatted on the way into the cit~~Given Article~~ ave me his business card. I ~~Article~~ elping me. Soon afterward, I rec~~Article~~ te that came with it said that ~~ful.~~	What happened when the author found smoke coming out of his car?
	QUESTIONS
Years later, I drove to a meeting in a nearby town in the morning. In late afternoon I returned to my car and found that I'd left the lights on all day, and the battery was dead.	The battery of the author's car was dead because __ .
Then I noticed that the Friendly Ford dealership - a shop selling cars - was right next door. I walked over and found two salesmen in the showroom. "Just how friendly is Friendly Ford?" I asked and explained my trouble. They quickly drove a pickup truck to my car and started it. They would accept no payment, so when I got home, I wrote them a note to say thanks. I received a letter back from one of the salesmen. No one had ever taken the time to write him and say thank you, and it meant a lot, he said. "Thank you" - two powerful words. They're easy to say and mean so much.	By telling his own experiences, the author tries to show __ .

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Prepare Sentences-Question (S-Q) pair (1)

- Sentences-Question extraction.
  - Extract the *relevant sentences* of one question from the article. (Make S-Q pairs for training.)
  - *Attention Model* in calculating relevant scores.
    1. Article & Question representation
       - Original Article → Separated Sentences
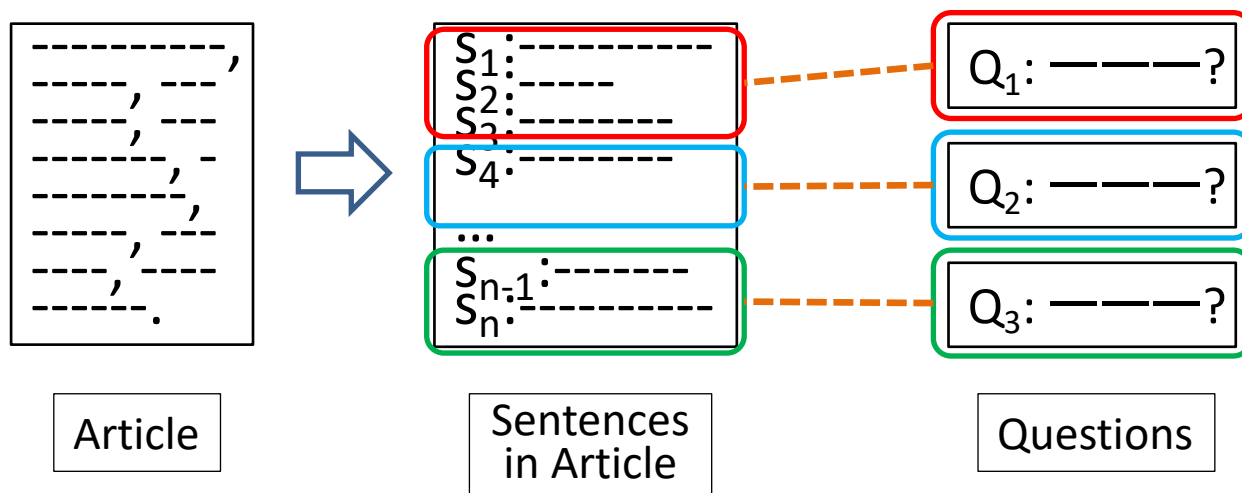
Prepare Sentences-Question (S-Q) pair (2)

– Original Question → Final Answer (use for extraction)

- Two types of question's asking style

1, with "_" blank of underline.

2, without blank.

| Original Question	Correct Answer	Final Answer
The bus school will _ .	go round from place to place	The bus school will go round from place to place.
What has happened to the animals on the earth?	Many kinds of animals have died out.	Many kinds of animals have died out.

Prepare Sentences-Question (S-Q) pair (3)

2. Train a Seq2Seq model with attention mechanism to generate the Final Answer from the input Article.

- Input: one article (s_1, s_2...s_n)
  – Enumerate the article with the number of questions.
  – Sentences in article were embedded by BERT.

- Output: one final answer (w_1,w_2,...w_n) (without mask)

Settings	Value
Input Max Length(Sentences)	40
Output Max Length(Words)	30
Vocab Size	28379
Attention Heads	1
Layer	1
Hidden Unit	1024
Learning Rate	0.0001
Dropout Rate	0.1
Article-FA Pairs	84224

One Question (Final Answer)

w1 w2 w3 ... wn

S1
S2
S3
S4
S5
.
.
.
.
Sn

One Article
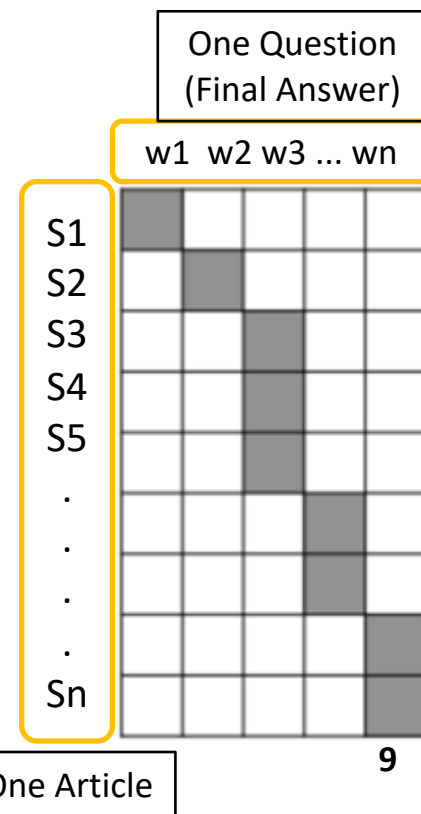
Prepare Sentences-Question (S-Q) pair (4)

3. Find out the most relevant sentences of one question.

- Get the attention scores of each word to sentences.

- Add up the attention scores of all the words in the final answer. $\sum_{w=1}^{n} Score(w|S)$

- Extract the top 5 sentences that have the highest scores.

 – In average, every 5 sentences have one question.

4. Get S-Q pair to prepare the training data of QG.

- Sort the extracted sentences through the order of the original article.

- Make the extracted sentences and the *original question* of the final answer as one sentences-question (S-Q) pair.

Original Question	Final Answer
The bus school will _ .	The bus school will go round from place to place.
What has happened to the animals on the earth?	Many kinds of animals have died out.

Sentences	Questions
Safari shuttle While you're here, take the Safari shuttle for a quick trip from one end of the Zoo to the other. All day long, every day every week (from 10 am to 5 pm), the Safari Shu**Sentences**o, and returns to the main flamingo ex serves a variety of Mexican food and refreshments . Silverback's Cafe offers sandwiches, salads, bread bowls, cold beer, and refreshments. from July 1 to September 7.	When **Question** can _ .

Training QG model (1)

- Sentences – Question pairs as training data.
- Transformer model of the Seq2Seq
  - Input: Sentences set (5 sentences at this time).
  - Output: One question.
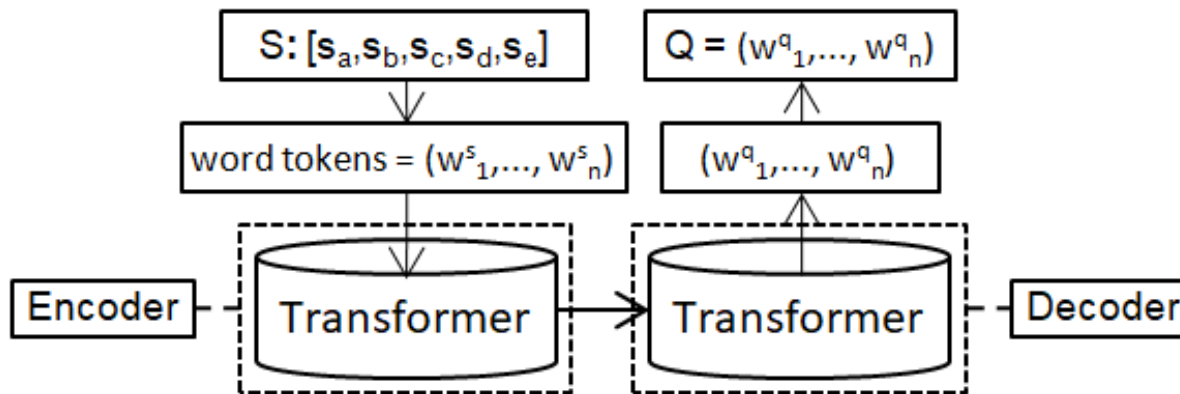
Encoder: $h_S = Transformer^l(S, W_q^{S,l}, W_k^{S,l}, W_v^{S,l})$

Decoder: $h_Q = Transformer^l(Q, W_q^{Q,l}, W_k^{Q,l}, W_v^{Q,l}, h_S)$

Task: $Q = Decoder(argmax\ P(h_Q|h_S))$

Training QG model (2)

- Common settings in training QG model

Settings	Value
Input Max Length(Tokens)	200
Output Max Length(Tokens)	30
Vocab Size	28379
Attention Heads	8
Hidden Unit	512
Learning Rate	0.0001
Dropout Rate	0.1
Sentences-Question Pairs	84224

- Three models with different Layer's setting

Experiment	Number of Layers	Batch Size	Epoch
A	4 layers	64	40
B	6 layers	50	40
C	8 layers	36	40

Types of the Generated Questions

- Types of the Generated Questions
  - Negative (Neg) question:
    The question cannot be answered or has non-sense with the given article.

  - Positive (Pos) question:
    The question could be answered through the given article.
    - Directly Related (DR) question:
      The description of the question owns the words or relevant phrases that directly related to the given article. (content-based)

    - Common (CM) question:
      The question that has a common sense and could be asked for many different articles. (irrelevant to specific article)

Output Result & Discussion (1)

- Evaluation
  - Statistics of 100 generated questions from 3 models.

Model	# of DR	# of CM	# of Pos (DR+CM)	# of Neg	Total
4-layers	21	33	54	46	100
6-layers	**24**	32	56	44	100
8-layers	14	**45**	**59**	41	100

  - Generated CM questions are always more than DR questions.
  - 4-layers and 6-layers model has the similar results.
  - 8-layers model tends to generate more CM questions.
  - Many reading comprehension questions are asked as the CM type in the language test.
  - Extensive existence of the CM questions may caused the tendency of the models' generation results.

Output Result & Discussion (2)

- Sample of the DR questions

Samples of the DR questions
why does the author ask the postman about his baby?
tea became a popular drink in Britain _ .
during the visit, visitors can _ .

- Sample of the CM questions

Samples of the CM questions
the passage mainly tells us that _ .
from the passage, we can learn that _ .
according to the article, which of the following is true?
what is the main purpose of the passage?
what would be the best title for the passage ?
the author's purpose of writing the passage is _ .

- For CM questions, the answer would be more difficult & important than that of the DR questions.

Conclusion

- Extract sentences-question pairs from reading comprehension articles to find the relevant correspondence & prepare training dataset.

- Use seq2seq model to generate questions from different part of the input article.

- Two types of questions' asking style in the language test. CM question & DR question.

- Future works:
  - Improve the relevant sentences extraction method
  - Deal with the CM & DR questions with different strategies respectively

Thank you!