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Saint Petersburg, Russia

Application of Natural Language Processing in Generating English Grammar Exercises

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Objective of this study

- Propose and Analyze architectures for generation of Reading Comprehension **(RC)** Questions
- Propose and analyze algorithms and architectures for generation of Fill-in-the-blank **(FITB)** based language learning exercises

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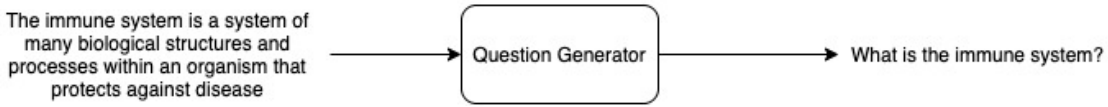
RC Question Generation

- Generation of Reading Comprehension Questions from the Sentences



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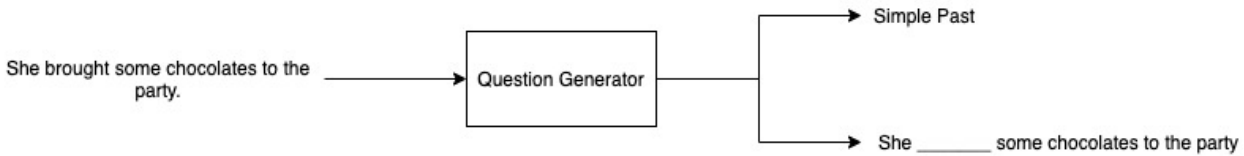
Fill-In-The-Blank Exercise Generation

- Different from RC
- Determine the position of blank in sentence or predict the blank word



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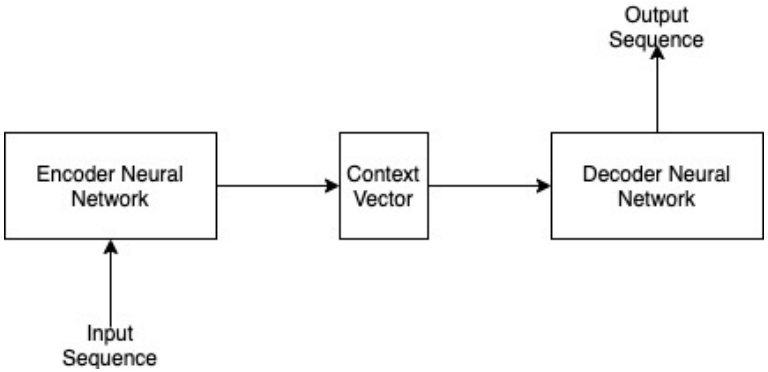
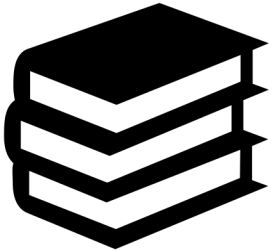
RC Question Generation Using Sequence to Sequence



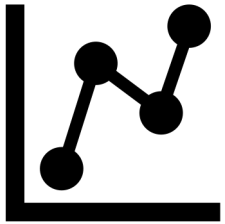
Literature Study

- Learning to Ask: Neural Question Generation for Reading Comprehension [*Du el at*] (2017)
- Neural Question Generation from Text: A Preliminary Study [*Zhou et al.]* (2017)
- Neural Models for Key Phrase Extraction and Question Generation [*Subramanian et al.*] (2017)
- Machine Comprehension by Text-to-Text Neural Question Generation [*Yuan et al.*] (2017)
- Unified Language Model Pre-Training for Natural Language Understanding and Generation [UniLM] [*Dong et al.*] (2019)
- Question Generation for Question Answering [*Dual et al.*] (2017)
- Question Generation by Transformers [*Kriangchaivech et al.*] (2019)



Evaluation Metrics

- **BLEU Score:**
  - Bi-Lingual Evaluation Understudy
  - N-grams overlapping between machine translation and reference translation.
  - Compute precision for n-grams of size 1 to 4
  - Used as Evaluation in previous attempts to generate Question
- **METEOR**
  - Uses F1 Measure to compute the values based on mapping of Unigrams
- **$ROUGE_L$**
  - Used more often in text summarization, takes account for Longest Common Subsequence.



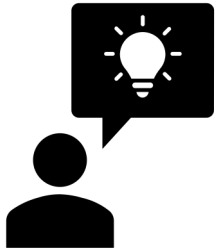
Dataset

SQUaD

- Stanford Question Answering Dataset (SQuAD)
- Reading Comprehension Dataset
- Consisting of Questions posed by crowd workers on a set of Wikipedia articles.
- Dataset Characteristics
  - Training Set: 70,484 Question and Answer Pairs
  - Validation Set: 10,570 Question and Answer Pairs
  - Test Set: 11,877 Question and Answer Pairs

Objectives

- Generate Reading Comprehension Based Questions
- Introduce Convolutional Seq2Seq Approach to generate Reading Comprehension Questions
- Comparative Analysis of performance of different architectures for RC Question Generation Task



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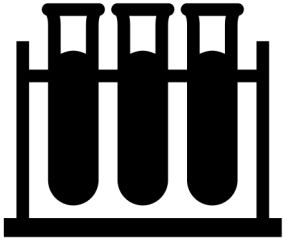
Experimentation



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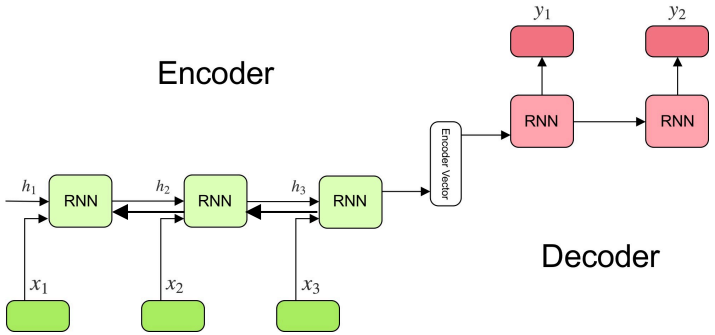
Experiment

Recurrent Sequence To Sequence

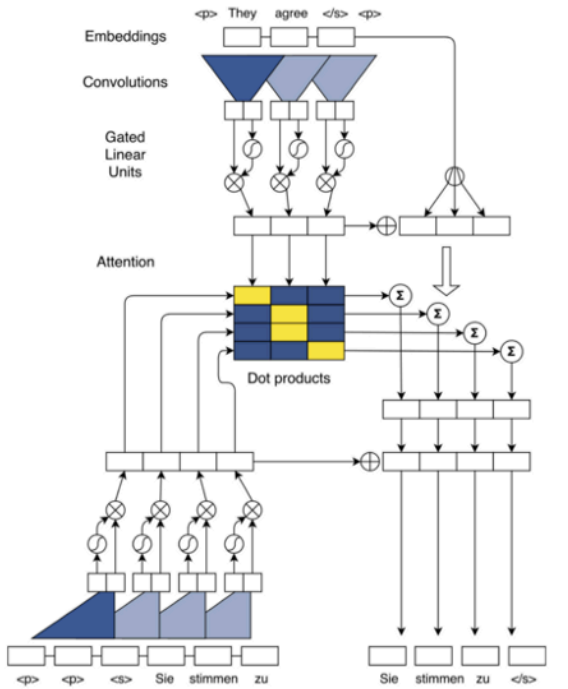
- Sequence to Sequence Learning with Neural Networks (2014) by Sutskever, I
- BiDirectional Encoder based on RNN Neural Network
- Used GloVe Embeddings
- Uses Attention to align the input and output sequences



Experiment

Convolutional Sequence To Sequence

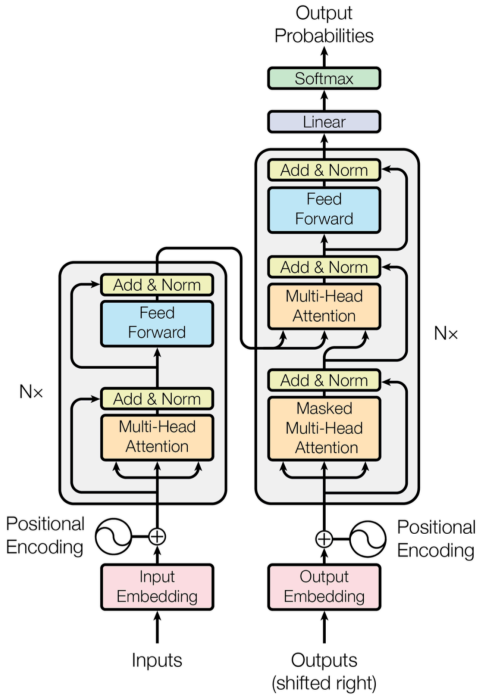
- Introduced in Convolutional Sequence to Sequence Learning (2017) by Gehring, J
- Encoder & Decoder contains Gated Linear Units & Residual Connections
- Used GloVe Embeddings
- Parallel Convolutions leads to faster training



Experiment

Transformer Encoder Decoder Network

- Introduced in Attention Is All You Need (2017) by Vaswani, A
- Encoder contains self attention and feed forward network
- Used GloVe Embeddings
- Decoder contains self attention, encoder-decoder attention layer and a feed forward network



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Result of Question Generation

Model	BLEU1	BLEU2	BLEU3	BLEU4	METEOR	$ROUGE_L$	Training Time (s)
Vanilla RNNSeq2Seq	31.34	13.79	7.36	4.26	9.88	29.73	--
RNN Seq2Seq	**34.17**	**18.51**	**11.78**	**7.92**	**12.97**	**33.72**	**3361**
CNN Seq2Seq	**32.23**	**16.65**	**10.34**	**6.78**	**12.57**	**32.35**	**1044.3**
Transformer Encoder-Decoder	27.74	11.32	5.96	3.48	7.24	27.2	2652.2

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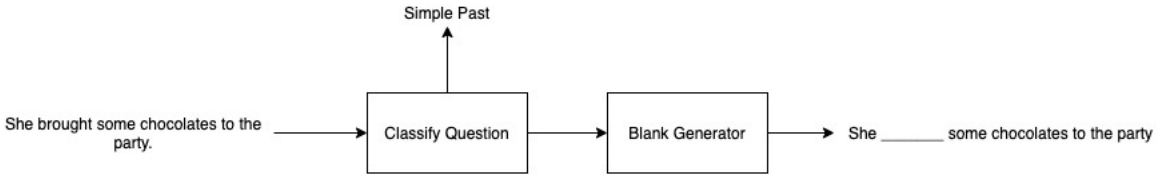
Example of Generated Questions

Sentence	Madonna was a pop singer, she was raised in a methodist household	
Ground Truth	What was Madonna raised in ?	
RNN	**CNN**	**Transformer**
Madonna was raised in what religion?	What was Madonna raised in?	What was the name of the name of the first child that was born ?

Example of Generated Questions

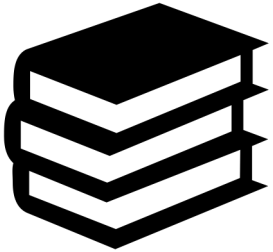
Sentence	Thomas Newman returned as spectre's composer	
Ground Truth	Who wrote the music for spectre?	
RNN	**CNN**	**Transformer**
Who returned as spectre's composer?	What was the name of the spectre's composer ?	What was the name of madonna 's career ?

Generation of Fill in the Blank Questions



Literature Study

- Gap-fill Tests for Language Learners: Corpus-Driven Item Generation [*Perez-Beltrachini et al.*] (2010)
- Measuring Non-native Speakers' Proficiency of English by Using a Test with Automatically-Generated Fill-in-the-Blank Questions [*Sumita et al.*] (2005)
- Learning to Automatically Generate Fill-In-The-Blank Quizzes [*Taylor et al*] (2018)
- Automatic Generation of Fill-in-the-Blank Programming Problems [*Terada et al*] (2019)

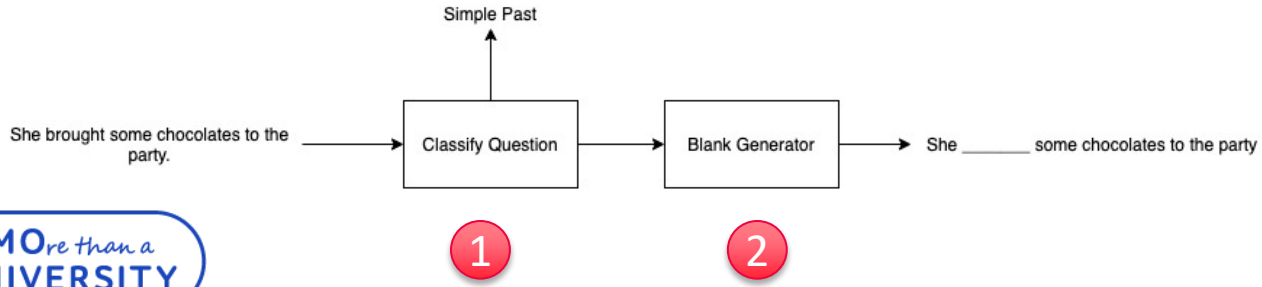


Dataset

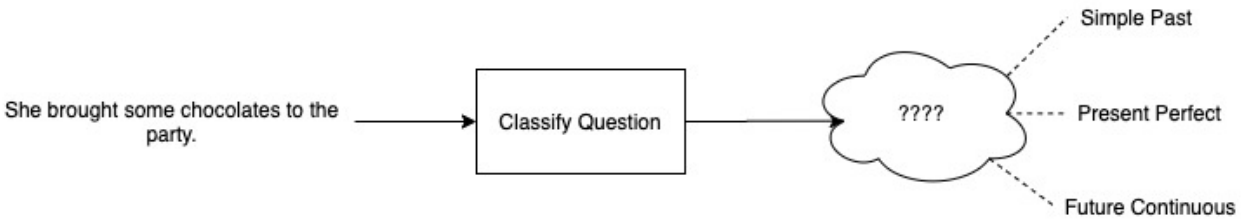
- Scraped dataset from online sources
- The dataset consist of columns: Question, key, answer, Type of Question
  - Trainset: 569 Question, Key, Answer and Type of Question Tuples
  - Test Set: 101 Question, Key, Answer and Type of Question Typles
- Type of Verb Conjugation Exercises Present: 11
- Example:
  - **Question:** Mother _____ the cake for my birthday party
  - **Key:** bring
  - **Answer:** Mother brought the cake for my birthday party
  - **Type of Question:** irregular verb

Methodology

- Two Step Approach
  1. Classify the nature of question
  2. Generate possible location of Blank
     - Sequence Labeling
     - Sequence To Sequence Generation



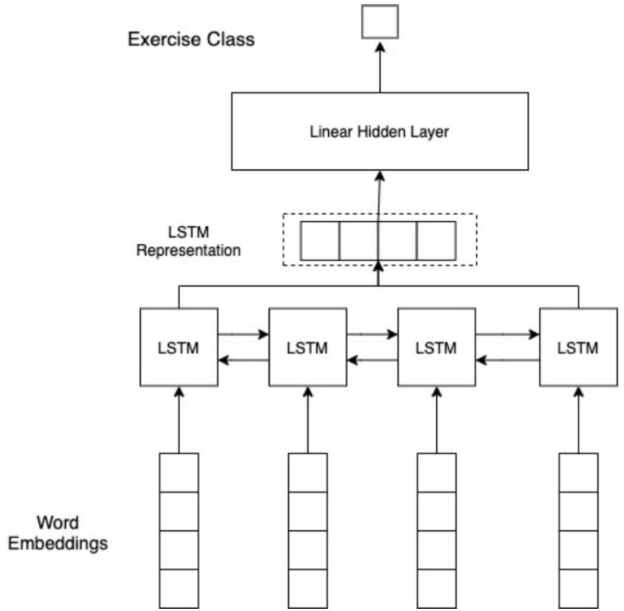
Classification of Nature of Exercise



Experiment

Bi-Directional LSTM Classifier

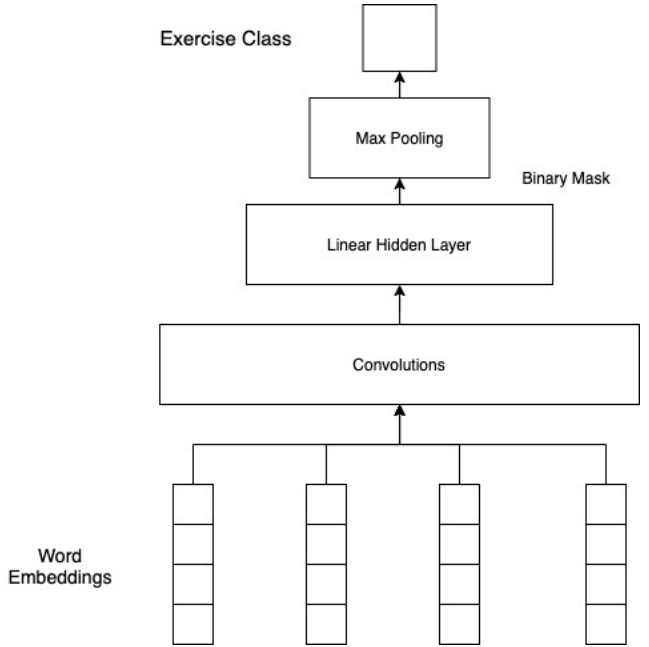
- Concatenating last hidden states of BiDirectional LSTM
- Predict the Nature of Exercise that could be generated from a given sentence
- Number of Trainable Parameters: 443,147



Experiment

Convolutional Classifier with Masking

- 1D - Convolutional Kernels of size 1, 3, 5
- Added a hidden layer after convolutions
- Trained using binary masks
- Number of Trainable Parameters: 199,115



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Result of Question Generation

Model	Classification Accuracy
Naive Bayes	78.22%
Support Vector Machine	81.19%
Logistic Regression	80.20%
Random Forest	76.24%
XGBClassifier	74.26
LSTM Classifier	79.24%
CNNClassifier	**84.29%**

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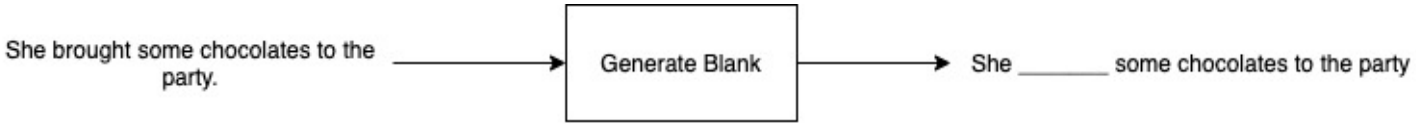
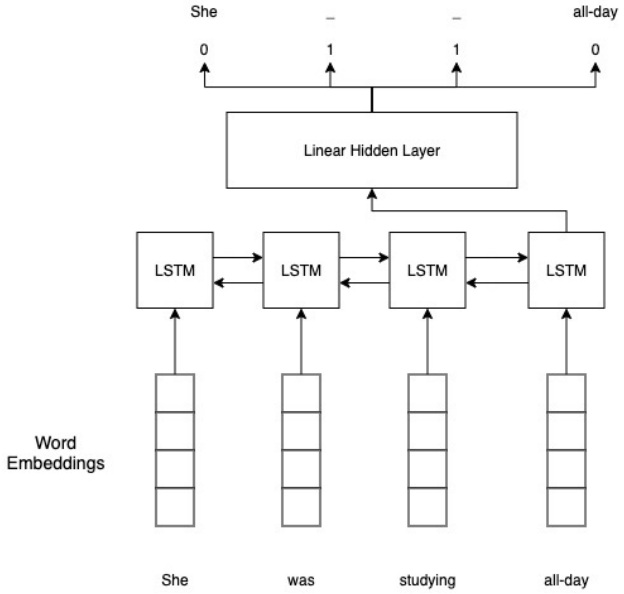
Fill in the Blank Generation



Fill in the Blank Generation

Sequence Labeling

- Classify that the token is a potential blank or not
- 0 is that the token is not a blank and 1 that the token is a blank
- Used RNN Based Classifier to classify each token



Fill in the Blank Generation

Sequence Labeling

- Compared our results with Automatic Generation of Fill-in-the-Blank Programming Problems [*Terada et al*] (2019)

Model	Precision	Recall	F1 Measure	Accuracy
FITBPP	0.66	0.73	0.69	--
Ours	0.61	**0.88**	**0.72**	**76.94%**

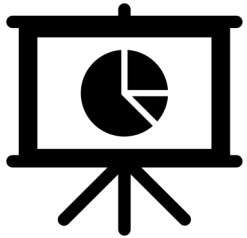
Fill in the Blank Generation

Sequence to Sequence Generation

Model	BLEU1	BLEU2	BLEU3	BLEU4	METEOR	ROUGE$_L$
NQG	43.09	25.96	17.50	12.28	16.62	39.75
RNN Seq2Seq	38.81	25.51	15.63	10.12	8.67	**44.6**
CNN Seq2Seq	37.10	23.12	12.02	6.77	8.13	**41.85**

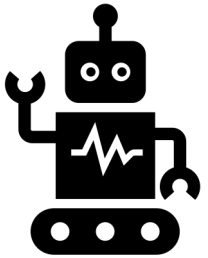
Conclusion

- Generated Reading Comprehension English Learning Exercise Questions as a Sequence to Sequence Problem with RNN based Seq2Seq Models and CNN based Seq2Seq Models
- CNN based Seq2Seq model performs comparably to generate Questions with RNN based models with faster training
- Fill in The Blank Exercises as a Sequence Labeling with an RNN based classifier
- Fill in the Blank Exercises as RNN and CNN based Seq2Seq models



Future Work

- Better evaluation metrics for FITB using Sequence2Sequence.
- Generation of more type of exercises with Sequence labelling
- Integration of Distractor Generation



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