Incorporating Self-Attention and Character Embeddings in a Question Answering System

Zhang, Melanie

CS 224N, Computer Science, Stanford University

Stanford Computer Science

Abstract

In this project, I aim to improve upon a baseline **contextual question-answering BiDAF SQuAD model** by using Context-to-Context **self-attention** and **character-level embeddings**. With the addition of a self-matching attention layer that receives question-aware context representations from the existing attention layer as input, the model is able to more effectively **gather evidence from the entire context** to help determine the answer. The existing embedding layer is extended with character-level embeddings, which allows the model to deal with **out-of-vocabulary tokens** and infer more meaning from contexts and questions containing them. The model is able to **improve upon the baseline EM and F1 scores substantially, achieving scores of 63.452 and 66.861 respectively.**

Problem

Question answering is a problem within NLP whose solutions allow users to formulate questions using natural language and receive an informative response. This has applications in **search engines**, **personal assistants**, and more.

The **SQuAD dataset** consists of paragraph, question, and answers crowdsourced using Amazon Mechanical Turk. Each answer is a span of the paragraph text. This project aims to improve on a provided baseline SQuAD model, by adding a **context-to-context self attention layer, character embeddings, and GRU encoding layers.**

Background

The baseline **BiDAF (Bidirectional Attention Flow for Machine Comprehension)** [1] model consists of:

- an **embedding** layer (with only word-level embeddings, although the original model uses character-level as well)
- **encoder** layer
- question-to-context and context-to-question **attention** layer
- **modeling** layer (another RNN encoder)
- **output** layer: probability distribution over the start and end positions of the answer span

This project adds **self-attention** to this baseline model:

- Self-attention is a paradigm that has seen great success in both RNN and Transformer models
- ***R-NET*** [2] incorporated **Context-to-Context** self-attention on top of a BiDAF model in 2017
  - landed first place on the SQuAD score leaderboard at the time of inception

I also add **character-level embeddings** to the model, as done in the original **BiDAF** and **RNET** models. This allows the model to better handle out-of-vocabulary words.

Methods

Context-to-Context Self Attention

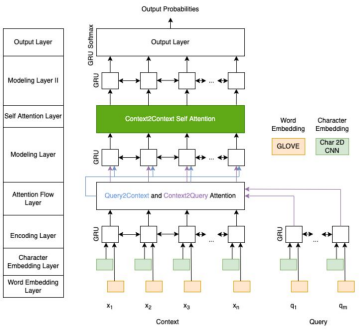
- We add a **Context-to-Context self attention** layer on top of the existing attention & modeling layers
- The outputs of the self attention layer are fed into 1+ **RNN encoder** layers

Embedding Layer

- We extend the existing embedding layer by using **character-level embeddings**
- Each word is split into characters which are embedded into vectors
- Each sequence serves as input into a **2D convolutional layer**
  - input channel size c_{in} = character embedding size
  - output channel size c_{out} = hidden size
- Resulting output is concatenated with the word embedding, **doubling the hidden size** of the original model

Other Model Changes

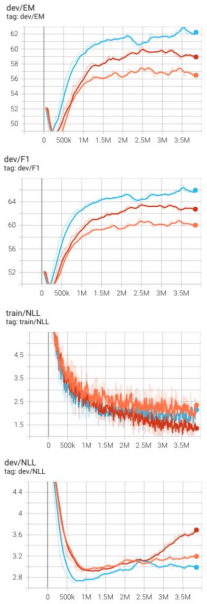
- Use **GRUs** in place of LSTMs in each encoder layer



Experiments

- To evaluate this model's performance, I utilized the train, dev, and test sets provided.
- The inputs and outputs to the model are **(question, context)** pairs and the outputs are **spans** of the given context.
- Other configurations:
  - LR 0.5
  - Dropout probability 0.7

Below are the **Tensorboard** graphs of train and dev **NLL**, as well as **EM** & **F1** dev scores during training. The **orange** line is the baseline model, **red** is character embeddings only, and **blue** is the final model.



Analysis

The baseline model made occasionally made syntactic and grammatical errors, e.g. punctuation truncation [An example answer: `T cell receptor (TCR`, which is missing a closing parentheses]. The model extended with character embeddings learns these grammatical patterns and improves upon the baseline.

The model extended with character embeddings **and** multi-headed self-attention improves upon question-answers that have longer contexts that require long-range dependencies within the context to answer the question. This is due to the fact that self-attention allows the model to effectively pool information across the entire context in each individual context word representation.

Conclusion

This project demonstrates the effectiveness of adding self-attention and character-level embeddings incrementally to improve a baseline SQuAD question answering model. My model is able to improve upon the baseline EM and F1 scores, achieving **scores of 63.452 and 66.861**.

References

[1] Ali Farhadi Hannaneh Hajishirzi Minjoon Seo, Aniruddha Kembhavi. Bidirectional attention flow for machine comprehension. In International Conference on Learning Representations (ICLR), 2017

[2] Microsoft Research Asia Natural Language Computing Group. R-net: Machine reading comprehension with self-matching networks. In Association for Computational Linguistics (ACL), 2017

Stanford University